

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application. Please cancel claims 1 through 28 without prejudice.

Listing of Claims:

Claims 1-28 (Canceled).

29. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor associated with the fluid conduit to detect air in the fluid passing along the fluid conduit of such infusion system and provide at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said conduit at a sampling time within the respective interval;

means for receiving the output signals and for calculating therefrom an air concentration value and for triggering remedial action when the air concentration value exceeds a predetermined value, comprising:

a memory for storing the air concentration value;

a processor which, each time the output signal is produced by the sensor, calculates a fresh air concentration value as the sum of (i) a raw value corresponding to the magnitude of the output signal and (ii) the product of the air concentration value stored in said memory and a weighting factor less than one, stores said fresh air concentration value in said memory in place of a previously stored air concentration value, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value has exceeded said predetermined value.

30. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor associated with the fluid conduit to detect air in the fluid passing along the fluid conduit of such infusion system and provide at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said conduit at a sampling time within the respective interval;

means for receiving the output signals and for calculating therefrom an air concentration value and for triggering remedial action when the air concentration value exceeds a predetermined value, comprising:

a memory for storing the air concentration value;

a processor which, each time the output signal is produced by the sensor, calculates a fresh air concentration value as the sum of (i) a raw value corresponding to the magnitude of the output signal and (ii) the product of the air concentration value stored in said memory and a weighting factor less than one, stores said fresh air concentration value in said memory in place of a previously stored air concentration value, compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value; and

a fluid control device adapted to receive said control signal and stop delivery of fluid along the fluid conduit when said air concentration value calculated exceeds said predetermined value.

31. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the time when the output signal was produced since the output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the longer the time which has elapsed since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value calculated has exceeded said predetermined value.

32. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal

corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the total volume of fluid dispensed through said conduit since that output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the longer the time which has elapsed since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value calculated has exceeded said predetermined value.

33. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated

information at least as to the place of the output signal in the chronological sequence of such output signals;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the longer the time which has elapsed since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value calculated has exceeded said predetermined value.

34. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the time when the output signal was produced since the output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the larger the amount of

fluid which has flowed through said conduit since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value calculated has exceeded said predetermined value.

35. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the total volume of fluid dispensed through said conduit since that output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the larger the amount of fluid which has flowed through said conduit since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value calculated has exceeded said predetermined value.

36. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information at least as to the place of the output signal in the chronological sequence of such output signals;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the larger the amount of fluid which has flowed through said conduit since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides an alarm signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

an alarm adapted to receive said alarm signal and operate when said air concentration value calculated has exceeded said predetermined value.

37. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the time when the output signal was produced since the output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the longer the time which has elapsed since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value; and

a fluid control device adapted to receive said control signal and stop delivery of fluid along the fluid conduit when said air concentration value calculated has exceeded said predetermined value.

38. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the total volume of fluid dispensed through said conduit since that output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the longer the time which has elapsed since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

a fluid control device adapted to receive said control signal and stop delivery of fluid along said fluid conduit when said air concentration value calculated has exceeded said predetermined value.

39. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information at least as to the place of the output signal in the chronological sequence of such output signals;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the longer the time which has elapsed since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

a fluid control device adapted to receive said control signal and stop delivery of fluid along the fluid conduit when said air concentration value calculated has exceeded said predetermined value.

40. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated

information as to the time when the output signal was produced since the output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the larger the amount of fluid which has flowed through said conduit since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value; and

a fluid control device adapted to receive said control signal and stop delivery of fluid along the fluid conduit when said air concentration value calculated has exceeded said predetermined value.

41. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information as to the total volume of fluid dispensed through said conduit since that output signal was produced;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of

the respective raw value and a weighting factor which is smaller the larger the amount of fluid which has flowed through said conduit since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values, compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

a fluid control device adapted to receive said control signal and stop delivery of fluid along the fluid conduit when said air concentration value calculated has exceeded said predetermined value.

42. (New) Apparatus for use in conjunction with a medical fluid infusion system for assessing the hazard to a patient connected to such infusion system of air in infusion fluid delivered along a fluid conduit of such system, the apparatus comprising:

a sensor adapted to detect air in fluid passing along the fluid conduit of such infusion system and providing at time intervals output signals, each output signal corresponding to the amount of air in a predetermined section of said fluid conduit at a sampling time within the respective time interval;

means, including a memory, for deriving and storing at least for a length of time encompassing a plurality of such time intervals, for each output signal, a raw value corresponding to the magnitude of the output signal, and for storing associated information at least as to the place of the output signal in the chronological sequence of such output signals;

a processor which, each time the output signal is produced, calculates, for each of the raw values stored in said memory, a respective weighted value equal to the product of the respective raw value and a weighting factor which is smaller the larger the amount of fluid which has flowed through said conduit since the corresponding sensor output signal was produced, calculates an air concentration value as the sum of said weighted values,

compares said air concentration value with a predetermined value, and provides a control signal if the air concentration value calculated exceeds said predetermined value;

a display connected with the processor for displaying said air concentration value;
and

a fluid control device adapted to receive said control signal and stop delivery of fluid along the fluid conduit when said air concentration value calculated has exceeded said predetermined value.

43. (New) The apparatus as in any one of claims 31-42, wherein the processor is arranged to calculate a primary air concentration value as the sum of said weighted values for a relatively long sequence of such output signals ending with the most recent and is arranged to calculate a secondary air concentration value as the sum of said weighted values for a relatively short sequence of such output signals ending with the most recent, or as the sum of said raw values for a relatively short sequence of such output signals ending with the most recent, and wherein the apparatus includes means arranged to compare said primary air concentration value with a first predetermined threshold and means arranged to compare said secondary air concentration value with a second predetermined threshold and to operate an alarm and terminate the supply of fluid along said conduit if either the primary air concentration value exceeds said first predetermined threshold or said secondary air concentration value exceeds said second predetermined threshold.